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Effect of Therapeutic Listening® Quickshift on Bilateral Coordination in Healthy Adults

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Table of Contents

List of Tables

List of Figures

Abstract

The purpose of this research study was to examine the influence of Therapeutic Listening® Quickshift on the bilateral coordination of healthy adults with no history of developmental or motor delays. Additional studies that demonstrate the effectiveness of the Therapeutic Listening® modality using measurable outcomes are necessary as many therapists currently use this program, even though few studies prove its effectiveness. This study recruited 14 freshman and sophomore students aged 18-21 years. Seven participants received Therapeutic Listening® Quickshift intervention one time for 20 minutes and seven received no intervention, but instead listened to white noise for the same duration. The participants received the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) bilateral coordination subsection before and after either the white noise or Therapeutic Listening® Quickshift protocol. Results demonstrated a slightly greater increase in scores for those who received the Therapeutic Listening® Quickshift intervention, however this difference was not statistically significant. Additionally, many participants received the maximum score on the pre-test and had no room for improvement on the post-test. This study was likely underpowered and the BOT-2 bilateral coordination subsection was not sensitive enough to measure change in a healthy, adult population. More sensitive assessment tools are needed to support future research in order to prove effectiveness of interventions through measurable outcomes that further evidence based practice in occupational therapy.

Introduction

Over the last two decades, occupational therapists have begun incorporating the use of sound as a therapeutic modality. These therapists use many different approaches to sound based intervention. Therapists must have research demonstrating the effectiveness and quality of different sound therapies in order to select the best sound based intervention. Currently, there is minimal research supporting the effectiveness of sound based therapies. Therapeutic Listening®, one of the more commonly used therapeutic sound modalities, has only three research studies supporting its effectiveness, even though therapists claim that this treatment approach positively influences therapy sessions (Vital Links Representative, personal communication, October 19, 2012). Sheila Frick created the Therapeutic Listening® system, a tool which uses modulated frequencies to affect change in brain wave frequencies. This affect brings the brain to a state of improved regulation. Thus affecting brain wave frequencies has the potential to affect how sensory information is processed and used. The Therapeutic Listening® Quickshift protocol is designed to affect bilateral coordination by influencing the aspects of the brain involved in this movement, such as the vestibular system and the inter-hemispheric communication of the brain (Vital Links Representative, personal communication, October 19, 2012).

When children have difficulty with an underreactive vestibular system, they sometimes have difficulty with bilateral coordination, or the coordination of the two sides of the body (Ayers, 2005). According to Ayers (2005), lack of hemispheric specialization can lead to difficulty with speech, writing, and reading. Bilateral coordination is required for many occupations. Improving bilateral coordination and sequencing has the potential to improve dressing skills, work skills, education skills, and social participation. Self-esteem may improve as well since children or adults are then able to interact with peers in sports activities, read in front of class, or assist in the completion of a complicated work task (Schaaf et al., 2010).

Therapeutic Listening®, has a wide range of reported benefits from assisting with focus for those with attention difficulties to improving body awareness and motor skill timing and sequencing (Frick & Young, 2009). Measuring improvements in attention and focus as a result of therapeutic intervention is difficult as these are intangible measures. Measuring improvement in motor skills using standardized assessments with good reliability and validity provides a tangible measure of effectiveness for therapists choosing sound therapies. This research study used standardized tools to measure the effectiveness of Therapeutic Listening®. This study had potential to assist therapists in making better clinical decisions regarding choice of sound based intervention by providing additional evidence regarding the effectiveness of Therapeutic Listening®. Researchers attempted to do this using the Bruinick-Osterescky Test of Motor Proficiency, Second Edition (BOT-2) to show improvements in bilateral coordination after an intervention of Therapeutic Listening® Quickshift. Demonstrating improvement in bilateral coordination through the use of Therapeutic Listening® Quickshift could opens doors for additional research and has the potential for improved participation in occupations. We anticipated that the Quickshift tool would demonstrate improved bilateral coordination, demonstrated by an improved score on BOT-2.

Literature Review

Sound has been utilized throughout history to heal individuals or decrease symptoms caused by illnesses or different conditions, as well as increase general wellbeing (Chan, Wong, Onishi, & Thayala, 2011). A wide range of sound based therapies, such as Binaural Beats, Mozart Effect, Tomatis Method®, Auditory Integration Training, Listening Program®, Samonas, Integrated Listening Systems, and Therapeutic Listening®, are available for use by therapists for children with atypical development (Cassity, Henley, & Markley, 2007; Corbett, Shickman, & Ferrer, 2007; Sinha, Silove, Wheeler, & Williams, 2006). These therapies use modified music or sounds that contain different frequencies, which researchers claim influences the brain (Nwora & Gee, 2009).

Therapeutic Listening® is commonly used by occupational therapists and other professionals when treating individuals with sensory integration difficulties (Hall & Case-Smith, 2007). Therapists report that Therapeutic Listening® is a beneficial treatment to use during therapy, with effects ranging from increasing a relaxed state to improving attention, spatial temporal organization, and coordinating movements (Frick & Hacker, 2001). Therapists have reported that Therapeutic Listening® is beneficial for children with sensory processing difficulties. However, limited research has been done to show the intervention's effectiveness (Hall & Case-Smith, 2007). There is some evidence supporting other sound based therapies' effectiveness, which makes therapists believe that further research will support the use of Therapeutic Listening® (Hall & Case-Smith, 2007). Therefore, more research needs to be done in order to test the effectiveness of Therapeutic Listening® Quickshift.

In this literature review we will discuss many different types of sound based therapy interventions that therapists have or are currently using as a form of treatment. Then we will discuss brain adaptations that occur when an individual listens to music or sounds at different frequencies. Next we will discuss different uses of sound based therapies and for which populations the therapies have been beneficial. Finally, because bilateral coordination is thought to be a key area of skill influenced by sound based therapies, we will explain its role in occupational function.

Sound Based Interventions

There are currently many different marketed techniques for sound based therapeutic intervention. For many of these interventions, there is either conflicting research or not enough research to assist therapists in making an educated decision regarding which type of sound based or listening intervention to try with their clients.

For example, the "Mozart Effect" (p. 47), documented by Rauscher, Shaw, and Ky (1995), is purported to be an increase in the ability to perform spatial-temporal reasoning, temporarily, after listening to Mozart. In a clearly titled study, "The Mystery of the Mozart Effect: Failure to Replicate," Steele, Bass and Crook (1999) discuss how they were unable to recreate the "Mozart Effect" (p.368) and found no significant increase on cognitive performance after listening to Mozart. However, they did discover that Mozart provided an elevation to participant's mood and this led them to hypothesize that, since mood can affect performance, Mozart's music may indirectly influence these scores (Steele et al., 1999). In another study, Cassity, Henley, and Markley (2007) found that listening to Mozart did not significantly increase video game skills, and that male participants completed the task more efficiently when listening to the video game's original soundtrack suggesting that the Mozart Effect may have more to do with individual mood.

The Tomatis® Method is another listening technique that relies on modulated music as method to stimulate the ear and influence the level of cerebral activity in the individual listening (Tomatis Developpment SA). By treating music with the "Tomatis Effect," the listening brain switches its focus between low frequencies (requiring little focus) and high frequencies (requiring additional focus) providing exercise to the ear and increasing effectiveness of sound transmission to the brain's sensory system (Tomatis Developpment SA). Researchers supporting the Tomatis® Method theorize that this frequency modulation assists the listener in focusing on language frequencies (Corbett et al., 2007).

Using a similar technique of modulating frequencies, Auditory Integration Training attempts to stimulate the auditory systems with the goal of improving the system's function (Berard AIT Website, 2012). According to the Berard AIT website, such improvement in sound processing can lead to a variety of other improvements in the individual undergoing the training including improved concentration (Berard AIT Website, 2012). However, AIT continues to be an experimental therapy and there are concerns that some of the sound level outputs exceed safe limits for listening (Sinha et al., 2006). It should also be noted that the term AIT does not consistently refer to Berard's work on Auditory Integration Training as the phrase is now used generically to describe different sound based interventions (Berard AIT Website, 2012).

In addition, several other sound interventions are based on the theories of Tomatis and Berard such as The Listening Program®, Samonas, and Integrated Listening Systems (ABT-Advanced Brain Technologies, LLC , 2012; iLs website, 2012; Listening Ears, LLC, 2008). Therapeutic Listening® incorporates theories from Tomatis and Berard and uses the Sensory Integration framework. According to Frick and Young (2009), the auditory system connects to many parts of the brain, which means that sound is one way to reach and influence the nervous system (Frick & Young, 2009). By this theory, listening is a "whole-brain, whole-body experience," (p. 3) one that is deeply connected to our ability to remain alert and in focused attention (Frick & Young, 2009). The Therapeutic Listening® system has several unique tools, each of which have specifically modulated sound spectrums that activate attention in the brain and help the nervous system to organize (Frick & Young, 2009). The Vital Links website (2012) states that Therapeutic Listening® is different than other sound based interventions because the therapy does not require that the client listen to the program in a set order. Instead, Therapeutic Listening® uses a variety of music that has been modulated to serve different purposes. Therapists determine the best music choice, or the best intervention to meet a child's specific needs. This allows the therapist to use his/her own clinical reasoning and judgment to determine the best choice of sound based intervention at the time of treatment.

In general, sound therapy works through applying special modulation to the music that shifts frequencies in a way that influences the brain. Some of these, including a series of sound interventions within Therapeutic Listening® called Gearshifters and Quickshift, use binaural beat technology to influence the brain wave frequencies of the listener, thereby altering the listener's state of alertness or focus (Frick & Young, 2009; Vital Links Representative, Personal Communication, October 19, 2012).

Brain Adaptation to Different Frequencies in Music

The brain is capable of adapting to auditory input. One method of manipulating music to influence brain waves involves the use of binaural beat technology (Wahbeh, Calabrese, Zwickey, & Zajdel, 2007b). By playing music through stereo headphones using two different frequencies, one on each ear, researchers believe one can "entrain" the brain, or cause the brain to mimic the difference between those two frequencies (Wahbeh, et al., 2007b p. 200). If each ear perceives a unique frequency, the listener will hear the difference between the two frequencies as binaural beats, or the offset of the two frequencies (Wahbeh, Calabrese, & Zwickey, 2007a). This in turn, causes the brain to synchronize to this frequency and increase the brainwave activity to match that frequency difference. For example, if one headphone plays a frequency of 500 hertz and the second headphone plays a frequency of 510 hertz, the brain will entrain to a frequency of 10 hertz. This creates an opportunity for researchers to manipulate brainwave activity for creating a relaxed state, reducing anxiety, or other therapeutic uses (Wahbeh, et al., 2007a).

When utilizing the Therapeutic Listening® Gearshifters series, the frequencies stay in the low alpha to low beta range of eight to 13 hertz (Frick & Young, 2009). According to Frick and Young (2009), this frequency range is ideal for relaxed focus and attention. The brain produces brainwaves across the spectrum of frequencies and these frequencies are associated with different levels of arousal (Table 1, Frick & Young, 2009, p.185). The frequencies in the music of the Gearshifters series entrain the brain, through the interaction of rhythm and sound on each side of the brain, to gain an increase in electrical activity in the alpha frequency range, promoting this relaxed focus (Frick & Young, 2009). According to Frick and Young (2009), when the two hemispheres of the brain begin to align their brainwave patterns, they also begin to move in a synchronous manner. The Gearshifters series can assist in this process, giving these interventions “the potential to set the stage for hemispheric synchronization, supporting bilateral integration on all levels, from motor skills to the whole-brain processing critical for learning and organized behavior” (Frick & Young, 2009 p. 186; Vital Links Representative, Personal Communication, October 19, 2012). Thus, listening to music specially modulated to produce alpha brainwaves has the potential to encourage a state of relaxed attention and focus in the listener, leading to improvements in functioning.

A variation of the Gearshifters series, called Quickshift, allows the therapist to do short versions of sound intervention focusing on specific concerns and creating immediate impact (Vital Links Representative, Personal Communication, October 19, 2012). In Therapeutic Listening® alone, there are several variations of sound based intervention that target a variety of clinical concerns such as difficulties with language discrimination, attention, core and praxis, and adaptive and social behaviors, among others (Frick & Young, 2009). Binaural beat technology promotes a brain state by entraining the brain to specific frequencies, however, the duration of treatment and brainwave patterns facilitated determine the function targeted by these specific sound based interventions (Frick & Young, 2009; Vital Links Representative, Personal Communication, October 19, 2012). In general, music and sound based interventions have and will continue to be used to treat a wide variety of diagnoses and promote many different skills.

Benefits of Sound Based Therapy Interventions

In recent years, various specialists, such as occupational therapists, speech therapists, and psychologists, have used sound based therapy as intervention methods, such as Therapeutic Listening®, in a variety of settings (Hall & Case-Smith, 2007). More specifically, therapists utilized sound based therapies as a treatment method for different psychosocial health issues (Scouarnec et al., 2001). Research demonstrated the benefits of sound based therapy on adults with different mood disorders such as depression and anxiety (Scouarnec et al., 2001). A recent study showed that sound therapy was effective in reducing anxiety levels for anxious adults, when they listened to binaural beat tapes (Scouarnec, et al., 2001). More specifically, binaural beat tapes decreased trait anxiety, which is a person's baseline anxiety level (Wahbeh et al, 2007a). In addition, researchers found that listening to music as a form of sound therapy is beneficial for adults who suffer from symptoms of depression, such as disrupted sleeping patters, low mood, low energy, poor concentration, low self esteem, loss of appetite, and poor self-care skills (Chan et al., 2011). Patients who received sound based therapy were able to decrease the amount of anti-depression medication they needed to take to control their symptoms. The decrease in anti-depression medication is beneficial because there are many side effects of this medication on older adults such as decreased psychomotor and cognitive functioning (Chan et al., 2011).

Recent research demonstrated that sound based therapy interventions are also beneficial in assisting with pain management in adult and geriatric populations (Guetin et al., 2012). Studies showed that listening to music as a sound based therapy intervention was beneficial in pain and medication management for individuals with chronic pain. Patients who received the therapy significantly decreased the amount of pain medication they took in order to control their pain levels (Guetin et al., 2012). Researchers found that listening to music as therapy is advantageous for pain management and decreasing anxiety about pain for adults before and after receiving spinal cord procedures, when compared to the adults who did not receive any sound based therapy (Lin, Lin, Huang, Hsu, & Lin, 2011).

Sound therapy has also been shown to be beneficial in increasing individual's abilities to complete tasks (Cacciafesta et al., 2010). Sound based therapy using Mozart music with older adults who had mild impairments in cognition improved their ability to complete cognitive tasks requiring spatial temporal skills (Cacciafesta et al., 2010). However, in order for these participants to maintain their improved function on cognitive tasks, the sound based therapy had to be continued over time (Cacciafesta et al., 2010). When comparing different types of binaural beats in the music used for the sound therapy, certain beats have a greater impact on improving task vigilance and mood while completing a task (Lane, Kasian, Owens, & Marsh, 1998). The participants who received binaural beats in the beta range of 16 to 24 hertz demonstrated less confusion and fatigue when participating in a task when compared to the control group who received binaural beats in the theta/delta range of 1.5 to four hertz (Lane et al., 1998).

In the field of pediatrics, researchers found that sound based therapy interventions improve a range of difficulties that children with sensory processing difficulties may demonstrate (Hall & Case-Smith, 2007). In one study, research showed that sound based interventions, such as Therapeutic Listening®**,** in combination with a sensory diet were beneficial for children in improving symptoms associated with Sensory Processing Disorders (Hall & Case-Smith, 2007). The children's auditory processing and behaviors associated with sensory processing difficulties demonstrated the most improvement after receiving the intervention. Specific behaviors associated with sensory processing difficulties that improved were attention, sleep patterns, social interactions, transitions, listening, self-awareness, and communication (Hall & Case-Smith, 2007). The research team also found that children's visual perception and hand writing legibility improved after a combination of Therapeutic Listening® and sensory diet treatments (Hall & Case -Smith, 2007). Another study looking at the effects of a sound based therapy intervention, specifically The Listening Program (TLP), on one child with pervasive developmental disorder-not otherwise specified (PDD-NOS) found improvements in sensory processing (Nwora & Gee, 2009). The greatest areas of improvement were the child's ability to process tactile input and the processing of different sensory systems at once (Nwora & Gee, 2009).

Researchers found that Therapeutic Listening® is beneficial in improving social skills for children diagnosed with developmental disabilities (Bazyk, Cimino, Hayes, Goodman, & Farrell, 2010). Teacher observations suggest that the children's ability to relate socially to the teachers and other students improved significantly. The teacher observations also stated that the children had a greater number of social interactions with their peers, including interactions that consisted of the participants smiling and laughing (Bazyk et al., 2010). The children also demonstrated increased participation in group activities with their peers. These research findings are consistent with the study done by Hall & Case-Smith (2007), that found Therapeutic Listening® when paired with a sensory diet improved the participants' social interactions with their peers.

Sound based therapy interventions were found to improve motor skills. Research looking at the effects of Therapeutic Listening® on fine and visual motor skills, found significant improvement in these areas (Bazyk et al., 2012). The participants' grasps improved after receiving the treatment. In addition, the participants scored significantly higher after the treatment when looking at their ability to copy different shapes (Bazyk et al., 2012). Nwora & Gee (2007) found that TLP was beneficial for a child with PDD-NOS in improving coordination of motor movement, bilateral coordination, and sequencing and timing of movements.

Bilateral Coordination

The Therapeutic Listening® Quickshift system influences bilateral coordination through the strong rhythmic qualities in its music and the inter-hemispheric coordination stimulated by such music (Vital Links Representative, Personal Communication, October 19, 2012). Bilateral coordination is the integration of movement on either side of the body to produce motor action

(Schaaf, et al., 2010). According to Koomar and Bundy (2002), there is little research on the development of bilateral coordination. Researchers do know that these skills begin in infancy and that humans gain the ability to produce individual bilateral movements before stringing them together in a sequence of movements (Koomar & Bundy, 2002). Additionally, the vestibular and proprioceptive systems play a role in how well humans are able to produce bilaterally coordinated movement patterns (Ayres, 2005; Schaaf et al., 2010).

Adequate bilateral coordination skills require adequate vestibular-proprioceptive skills (Schaaf, et al., 2010). The vestibular system helps humans maintain balance and equilibrium, align the head and eyes appropriately to compensate for movements, and helps humans navigate sensations of speed and direction (Schaaf et al., 2010). When the vestibular system is not working well, deficits in bilateral coordination may appear such as poorly coordinated movement, confusion between left and right, and inability or avoidance of the individual to cross midline. Proprioception refers to an awareness of the body's position in space and helps humans determine force and timing of activities (Scaaf et al., 2010). A poorly functioning proprioceptive system can also affect bilateral coordination by making it difficult to adjust the body's position and posture, causing the individual to have low endurance, or making it difficult to determine timing and force required for activities. In addition, if the vestibular system is not functioning well, there is potential for a disruption in the hemispheric specialization the brain typically undergoes during child development (Ayers, 2005). This means that both sides of the brain are doing the same thing rather than specializing for unique functions. This in turn can lead to two sides of the brain and body that have difficulty functioning as a natural unit (Ayers, 2005).

In a study exploring the gross motor skills of children adopted from orphanages, researchers found that children who were deprived of motor activity at a young age continued to show deficits, specifically in balance and bilateral coordination, after spending six years or more with their adopted families (Roeber, Tober, Bolt, & Pollack, 2012). Roeber, et al. (2012) note that many of these motor deficits are large enough to qualify these children for occupational or physical therapy. Researchers believe these early experiences of motor exploration are critical for overall neurobehavioral development and may later lead to being isolated from social activities (Roeber, et al., 2012). Researchers found this to be true with other sensory systems as well, noting that depriving children of sensory stimulation may actually cause dysfunction with sensory integration abilities (Ayres, 2005). However, Roeber et al. (2012), were careful to mention that the evidence supporting that deprivation connects to motor delays does not mean that any dysfunction is permanent, but it does mean that specific therapy may be required to assist in appropriate motor development later in life.

Ayers (2005) also points out that the child with deficits in bilateral integration may have difficulty with dancing, rhythm, or any other activity coordinating both sides of the body. This child may also have delays in speech, reading, and writing as well, as the two hemispheres are lacking specialization. Each hemisphere tries to do the same task, but without communication between the two sides of the brain, the development may be inadequate (Ayers, 2005). This can also lead to difficulties with daily grooming and dressing activities and potentially problems with self-esteem as the children see their failures during various daily activities (Schaaf, et al., 2010).

Standardized assessments provide a method for testing how well an individual can perform tasks requiring bilateral coordination. One such assessment, the SIPT, or Sensory Integration and Praxis Test, tests the function of bilateral integration and sequencing from various sensory systems (Ayres & Marr, 2002). This test includes subsections that address preferred hand use and standing and walking balance in addition to bilateral motor coordination (Ayres & Marr, 2002). The Bruininks Oseretsky Test of Motor Profiency (BOT) also has a subsection that tests bilateral coordination (Balakrishnan & Rao, 2007). This subtest includes tapping and jumping tasks using synchronized movements on either side of the body in both symmetrical and asymmetrical patterns (Balakrishnan & Rao, 2007). The second edition of the test assesses ages four through 21, making it an accurate assessment for bilateral coordination skills of young adults (Pearson Education Inc., 2012).

Conclusion

Research found many types of sound based therapies are beneficial when therapists used them when treating patients in a variety of settings (Hall & Case-Smith, 2007). Although research available on sound based therapy interventions, there are gaps in current research specifically looking at Therapeutic Listening®'s effectiveness (Hall & Case-Smith, 2007). In addition, there are also inconsistencies in current research studies about whether or not certain sound based therapies are effective. These inconsistencies could be due to many of the studies having small sample sizes and limited generalizability due to the lack of diversity among sample the research teams studied (Carter, 2012; Nwora & Gee, 2009; Steele et al., 1999; Wahbeh et al., 2007a). Future quality research needs to be done to determine whether or not Therapeutic Listening® is an effective therapeutic intervention.

More specifically Therapeutic Listening® Gearshifters uses binaural beats to provoke different arousal levels (Frick & Young, 2009). Manipulating arousal levels can be conducive to assisting a person in completing different functions, such as being relaxed and able to attend to a certain task (Frick & Young, 2009). Therapeutic Listening® Quickshift are used in order to target specific deficits in a shorter amount of time, such as difficulty with bilateral coordination (Vital Links Representative, Personal Communication, October 19, 2012). Bilateral coordination is important because it helps integrate both the left and right sides of the body during body movements and thus is essential for daily activity (Kramer & Hinojosa, 2010). Research examining the effects of Therapeutic Listening® Quickshift on bilateral coordination can be beneficial in demonstrating the effectiveness of Therapeutic Listening®.

Statement of Purpose

The purpose of this research was to examine the influence of listening to modified music using binaural beat technology (the Quickshift, one tool in Therapeutic Listening®) on the bilateral coordination of healthy, young adults with no history of developmental or motor delays. Many therapists use Therapeutic Listening® Quickshift as a therapeutic intervention, but there are currently only three studies that look at its effectiveness. The overall goal of the research was to answer the following questions: (1) Why is it beneficial for occupational therapist to choose Therapeutic Listening® Quickshift as an intervention approach? (2) How can we effectively measure improvements as a results of Therapeutic Listening® Quickshift? (3) How do we demonstrate effectiveness of Therapeutic Listening® Quickshift on bilateral coordination? However, the goals specific to this research study were: (1) Does Therapeutic Listening® Quickshift improve bilateral coordination as measured by scores on the BOT-2 bilateral coordination subsection in healthy young adults? (2) Does Therapeutic Listening® Quickshift improve the listening experience and comfortability with performing motor tasks in healthy adults? (3) Does Therapeutic Listening® Quickshift improve the quality of movement during bilateral coordination tasks?

This study began by researching the effectiveness of Therapeutic Listening® Quickshift on bilateral coordination, since observed evidence indicates that this intervention improves bilateral coordination in healthy adults (Vita Links representative, personal communication, October 19, 2012). This research team chose bilateral coordination, because it is tangible and can clearly be measured. These questions were answered by collecting data on two groups, one experimental and one control group, from young adults at Dominican University of California who received, as part of this research, the Therapeutic Listening® Quickshift intervention. The researchers hypothesized that Therapeutic Listening® Quickshift would improve bilateral coordination in healthy young adults after one treatment session as demonstrated by improved scores on the BOT-2.

Theoretical Framework

Sensory Integration Theory

Sensory Integration (SI) is a frame of reference that describes the neurological process of how the central nervous system (CNS) organizes sensory information from our bodies and the environment (Frick & Young, 2009). SI is a process that, when working properly, occurs unconsciously, like a person's ability to breath without thinking (Ayres, 2005). Once the CNS receives the sensory information from different sensory systems, the brain then organizes the information in order for the body to respond appropriately (Ayres, 2005). The integration and organization of the sensory information is important for a person's ability to participate in a range of occupations.

Jean Ayres, an occupational therapist with degrees in neuroscience and educational psychology, developed the SI frame of reference (Schaaf et al., 2010). Ayres developed SI while researching behaviors of children with learning disorders, because she felt that other theories did not adequately explain why certain behaviors were displayed in these children, such as deficits in interpreting sensations. Ayres emphasized that SI begins early on when children are in their mother's womb. As children get older, their ability to interact with the environment and experience different sensations helps to further develop their ability to integrate sensory information (Schaaf et al., 2010). Ayres also emphasized that our sensory systems do not work in isolation from one another, and that sensations from one sensory system will impact another sensory system. The integration of the different sensory systems is key to providing people with the needed information to learn and develop new behaviors (Ayres, 2005).

A person's ability to integrate and organize sensory information helps him/her focus on important sensations and filter out unneeded sensory information (Ayres, 2005). Being able to filter out unneeded sensory information makes it possible for someone to make an adaptive response in regards to important stimuli, especially from the environment. An adaptive response is a goal-directed and purposeful action in response to sensory stimuli, such as a child reaching or crawling for a toy. As the child's sensory integration further develops, their skills and adaptive responses become more complex (Ayres, 2005).

Ayres also believed that children learn by being provided the "just right challenge" (p. 106), which is "an activity that has the capacity to build new skills and abilities while adjusting for the current level of function of the child" (Schaaf et al. 2010, p. 106). If the activity is too easy or hard, the child will be less likely to want to participate, decreasing the opportunities for the child to learn new skills (Schaaf et al, 2010). Providing a child with "just right challenges" (p. 106) combined with a child's ability to filter different sensory stimuli and produce adaptive responses makes it possible for the child to successfully participate in different occupations (Schaaf et al. 2010).

Sensory systems that provide the CNS with information are vision, auditory, gustatory, olfactory, tactile, vestibular, and proprioception (Ayres, 2005). Ayres postulated that the three primary sensory systems contributing to SI are the tactile, proprioception, and vestibular senses (Frick & Young, 2009). The tactile system is the largest sensory system due to the amount of skin and touch receptors that cover the body. The tactile system provides information to the brain from skin receptors in relation to touch, pressure, texture, and temperature (Ayres, 2005). The proprioceptive system lets a person know the position of their body at rest and during movement. The compression and pulling on the joints and the contraction and stretching of the muscles in the body are what make people aware of where their body is in space. The body awareness provided by the proprioceptive system makes it possible for people to do certain skills such as walking, writing, and sitting in a chair. These skills are important and necessary for a person to participate in occupations (Ayres, 2005). The vestibular system provides information of head movement, balance, and the effects of gravity on the body. The vestibular receptors are located in the inner ear and send messages to the brain whenever there is movement of the head (Ayres, 2005). The messages allow the body to know where the head is in relation to gravity, whether or not the body is moving, and the speed and direction that the body is moving. The vestibular system, in combination with other sensory systems, allows a person to maximize function in order to participate in occupations that require good posture, balance, and movement (Ayres, 2005).

The vestibular and proprioceptive systems more specifically affect bilateral coordination. Bilateral coordination is defined as a person's ability to use both sides of the body and the trunk at the same time during motor activities (Koomar & Bundy, 2002). Basic activities that require bilateral coordination are clapping, opening a container, or riding a bike (Schaaf et al., 2010). Before individuals can coordinate movements of both sides of the body, they need to know their bodies' position and movement in space, which are sensations provided from the vestibular and proprioceptive systems. As the ability to utilize bilateral coordination continues to develop, more complex skills are developed such as the ability to kick or catch a ball while moving (Koomar & Bundy, 2002).

The auditory system is important especially in relation to Therapeutic Listening® Quickshift (Vital Links Representative, Personal Communication, October 19, 2012; Frick & Young, 2009). The auditory system sends messages to different areas of the brain to integrate information from other senses and messages from the motor system (Ayres, 2005). The integration of auditory input with the other senses, especially vestibular, is what allows individuals to make sense of what they hear (Ayres, 2005). The auditory system is also closely related to the motor system (Frick & Young, 2009). Movement enhances the perception of sound and movement of the body is prompted by auditory sound (Frick & Young, 2009). Due to the auditory system integrating with other senses and the motor system, Therapeutic Listening® utilizes the auditory system to organize and integrate the nervous system for function (Frick & Young, 2009).

Sensory Based Motor Disorders

Disorders of the sensory system can affect many areas of function, but for the purpose of this research the focus is on motor based disorders (Reeves & Cermak, 2002). One area impacted is known as praxis, which is an individual’s ability to plan, create, and execute adaptive motor responses in reaction to the demands of the environment (Schaaf et al., 2010). In order for praxis to work correctly, adequate reception, discrimination, and integration of all the senses are needed in order for people to plan for the appropriate motor response. Praxis is especially important for motor responses when people are doing daily or routine tasks that are usually effortless and automatic. If an individual has dysfunction of his/her praxis, it is known as Dyspraxia. People with dyspraxia have difficulty participating in certain occupations or tasks that require a lot of thought, which limits these individuals ability to participate in these tasks (Schaaf et al., 2010). Another motor area that is impacted is bilateral integration and sequencing (BIS) (Reeves & Cermak, 2002). Researchers have found that BIS difficulties are directly related to the vestibular and proprioceptive systems. Difficulties in bilateral coordination and sequencing can lead to problems crossing midline, failure to develop hand preferences, and left and right directional confusion (Bundy, 2002).

We used SI frame of reference to guide our research in determining whether or not Therapeutic Listening® Quickshift is beneficial in improving bilateral coordination. Sheila Frick created Therapeutic Listening® sound-based interventions with a basis in the SI frame of reference (Frick & Young, 2009). The sound-based interventions utilize the auditory system in order to makes changes to the brain that would affect a person's sensory system. Gearshifters and Quickshift are thought to manipulate brainwave frequencies and synchronize the brainwave patterns in the right and left hemispheres of the brain (Vital Links Representative, personal communication, October 19, 2012). The synchronization of both hemispheres of the brain will increase a person's ability to bilaterally integrate both sides of the body (Frick & Young, 2009). Gearshifters and Quickshift are also known to change brainwave frequencies to an alpha state that helps organize the brain and modulate the different sensations (Vital Links Representative, personal communication, October 19, 2012). Since SI focuses directly on the organization of the brain and how it affects different movements, specifically bilateral coordination, SI was considered the best frame of reference to guide our research.

Methodology

Design

This research thesis used a quantitative, experimental, pre-test-post-test control-group design. Since this is a pilot study, a small descriptive component is included. Participants were randomly assigned to either the control or experimental group using a random number generator. All participants received the bilateral coordination subsection of the Bruininks-Osterestsky Test of Motor Proficiency second edition (BOT-2) assessment before and after the auditory intervention. Auditory intervention consisted of listening to the Therapeutic Listening® Quickshift digital music over headphones for approximately 20 minutes. Participants who did not receive treatment listened to white noise for the same amount of time, using the same headphones as participants receiving treatment. The independent variable for this study is the Therapeutic Listening® Quickshift auditory intervention and the dependent variable is the BOT-2 bilateral coordination subsection score.

Subjects

The target population was healthy adults aged 18-21 years. The study used a convenience sample from Dominican University of California's introductory courses consisting of courses for biology, occupational therapy, public speaking, and psychology. The study recruited 14 freshman and sophomore students, aged 18-21, with a mean age of 19 years old. One male and 13 female students participated in the study. Participation in the study was voluntary. The research team randomly assigned students to either the experimental or the control group using random number generation. Fourteen healthy young adults from Dominican University of California completed this research study.

Permission was obtained from four Dominican University of California professors to recruit from their classes. The team went to each class, explained the nature of the study, and asked for volunteers. Informed consent was obtained before beginning procedures. A separate consent for videotaping was included. This research team then used a questionnaire to assess if the student participants met the inclusion criteria. This form asked for age, gender, if participants have any physical limitations or injuries that may hinder safe completion of jumping or movement activities, any difficulty processing sensory information, or any other known condition or diagnoses that may affect cognition, attention, or hearing.

Dominican University of California is a private university founded in 1890 (Dominican University of California, 2012a). The school has approximately 2,278 students. Ninety percent of Dominican University's students are from California, 6% from other states in the country, and 3% are international students. Dominican University's undergraduate program is 73% female and 27% male (including both full and part time students) (Dominican University of California, 2012b). Forty percent of Dominican University's population describe themselves as white, 18% Hispanic, 15% Asian American, 4% African American, and 23% identify as "other." Ten percent of Dominican University's students are from very low-to-low income status families (Dominican University of California, 2012a). The demographics of this study therefore closely match the demographics of Dominican University of California and did not necessarily represent the generalized population.

There were no restrictions for inclusion based on gender, race, ethnicity, or economic background. Since the target population of this initial study was healthy young adults, exclusion criteria included students with learning disabilities, physical disabilities, or disabilities with attention or sensory processing. Subsequent studies may choose to include students with diverse abilities. Data for inclusion and exclusion criteria were collected using an inclusion criteria selection form (Appendix A).

Ethical Considerations

To ensure the protection of participants' rights, this study gained IRB approval before commencing. This research team also adhered to the American Occupational Therapy Association's (AOTA) *Occupational Therapy Code of Ethics* (2010) and the Dominican University of California *Institutional Review Board for the Protection of Human Subjects Handbook* (2006). Through doing so, this research team contributes to the field of occupational therapy research in a manner that is truthful, respectful, and professional. This study targeted healthy, young adults and did not require the participation of any vulnerable populations. During the experiment, the room used was large enough to safely perform the motor task demonstrating bilateral coordination. In addition, the volume of the auditory intervention was a safety consideration for this study. Frick and Hacker (2001) recommend a volume level similar to that of a normal speaking voice for the Therapeutic Listening® program. The research team tested the listening volume using an audio monitor prior to intervention to ensure did not exceed this recommendation.

The researchers provided proper disclosure as to the nature of this study and gained informed consent of each participant before beginning the experiment (Appendix B). The researchers also notified the participants of their right to withdraw from the experiment at any time should they desire. This study maintained participant confidentiality by recording final results using identification numbers unique to this study. This research team stored data on a password protected computer drive to which only the research team had access. Video recordings of participant images were stored in the same fashion and identified only by unique identification numbers. Lastly, this research team requested permission when recruiting participants from the university, requesting a space to perform the experiment, and using copyrighted and protected materials. Protected materials include the standardized assessment, Bruininks-Osteresky Test of Motor Proficiency Second Edition® and the Therapeutic Listening® System: Quickshift.

Data Collection

This study obtained permission from Dominican University of California to recruit and test students. This study required the use of a classroom on campus for testing. The study also required and obtained written permission from the professors of the four classes to recruit students from their classrooms.

After eligibility was determined, participants were randomly assigned to the control or experimental group.

Therapeutic Listening® Quickshift protocol.

The Therapeutic Listening® Quickshift protocol is a series of songs with specially modulated music designed to promote hemispheric synchronization and bilateral coordination (Frick & Young, 2009). The research team provided an approximately 20 minute session of the Therapeutic Listening® Quickshift listening program to the experimental group using the accompanying HD500A Sennheiser Headphones. These headphones are an important tool to the Therapeutic Listening® program as they were specifically designed for this program (Vital Sounds, LLC, 2006). The control group used the same headphones, but listened to white noise (Ramirez, n.d.) instead of the Therapeutic Listening® program.

Measures.

The Bruininks-Osterestsky Test of Motor Proficiency, second edition (BOT-2) was used as the primary measure of bilateral coordination (Pearson Education Inc., 2012). The bilateral coordination subsection of the BOT-2 includes seven items scored as a raw number for number of successful attempts of the item that is then translated to a point score (Pearson Education Inc., 2012). Three items include touching the nose with alternating fingers with vision occluded, jumping jacks, and pivoting fingers with thumb and index finger touching. The other four items include an activity done in symmetry followed by that same activity done asymmetrically (Pearson Education Inc., 2012). The participant must jump with the right arm and leg forward followed by the left arm and leg forward, but in a fluid motion, then alternate right leg with left arm and left leg with right arm. The participant also must tap the right index finger and right foot followed by the left index finger and left foot in a fluid motion, then alternates right finger and left foot and left finger and right foot (Pearson Education Inc., 2012). Participants are provided with two trials to complete the item. The reliability and validity of the BOT-2 is well established by its authors and reported in the BOT-2 manual (Pearson Education Inc., 2012) .

Video performance of the BOT-2 was recorded for later analysis. Students, who did not consent to videotaping, were still eligible to participate in the study. The video recordings were reviewed for the quality of movement performed during the pre and post BOT-2 test. The video recordings provided the results a qualitative element to aid the understanding of the results.

The Survey completed by the participants following the experiment (Appendix B) asked participants four. The questions were:

1 Before listening to music, I felt [circle one: comfortable/uncomfortable] performing the motor tasks asked of me. Please describe:

2 While listening to music, I felt [circle one: comfortable/uncomfortable]. Please describe:

3 After listening to music, I felt [circle one: comfortable/uncomfortable] performing the motor tasks asked of me. Please describe:

4 My overall rating for this experience is: [circle one: comfortable/uncomfortable].

Data Analysis

A series of two by two (trail by group) repeated measure ANOVA were conducted to examine group differences in pretest and posttest scores on the BOT-2 bilateral coordination subtest. An independent *t*-test was used as follow-up teats to analyze the mean change in the BOT-2 bilateral coordination subtest scores between pre-test and post-test within the control group and the experimental group. Alpha levels for a two-tailed t-test are at .05. This study reports on the observations of the video performances of the participants completing the BOT-2 and the surveys completed by the participants. These are descriptive components of the study intended to aid the reader's understanding of the results by providing description about the quality of movement during the BOT-2 and how this improved from the pre-test to the post-test when the research team applied the Therapeutic Listening® intervention.

Results

Fourteen healthy young adults from Dominican University of California completed the study. Seven individuals listened to white noise and were part of the control group and seven individuals listened to the Therapeutic Listening® Quickshift program and were part of the experimental group. All participants completed the pre-test and post-test procedures using the second edition of the Bruininks Oseretsky Test of Motor Function (BOT-2), bilateral coordination subsection, participated by listening to the intervention or white noise, and completed the final survey regarding comfort with the sound therapy and movement tasks. Thirteen participants consented to being videotaped pre-test and post-test.

This research study collected data to answer three research questions:

Research question number 1: Does Therapeutic Listening® Quickshift improve bilateral coordination as measured by scores on the BOT-2 bilateral coordination subsection in healthy young adults?

Total points score.

Both the control and experimental groups increased scores between the pre-test and post-test (see Table 2). There was a slightly larger increase for the experimental group from pre to post-test; however, this increase was not significant (see Figure 1). A two by two (test time by group) repeated measure ANOVA was conducted to compare total points scores on the BOT-2 bilateral coordination subtest within pre-test and post-test trials and between groups that received Therapeutic Listening® Quickshift and the control group that received a treatment of white noise. The differences were not significant interaction between groups by test time ($F_{(1,12)}$ = .529, *p*= .48, partial eta squared=.042).

Item Scores.

Examining individual item scores on the bilateral subsection of the BOT-2 revealed a strong ceiling effect on pre-test or post-test for most items. As noted in Figure 2, the only two items demonstrating variability in the pre-test are the finger pivot and asymmetrical tapping. For all other items, participants completed the item with 100% success in the pre-test and post-test. Only two items in the bilateral subsection of the BOT-2, finger pivot and asymmetrical tapping, did not have a consistent ceiling effect (see Figure 2).

Asymmetrical tapping had the greatest variability in the scores between pre and post-tests. A repeated measure ANOVA compared groups on pre-test to post-test performance scores The differences were not significant between groups by test time ($F_{(1,12)} = .480$, $p = .50$).

The finger pivot item also demonstrated variability in the pre-test. However, there was no variability between the pre-test and the post-test. A repeated measure ANOVA compared groups on pre-test to post-test performance scores. The differences were not significant between groups by trail ($F_{(1,12)} = .00$, p= .1.00).

Research question number 2: Does Therapeutic Listening® Quickshift improve the listening experience and comfort with performing motor tasks in healthy adults?

The researchers asked participants four questions following the experiment in the form of a survey. Before listening to Therapeutic Listening® Quickshift or white noise, eight participants reported feeling comfortable, five reported feeling uncomfortable, and one did not respond to the question. While listening to Therapeutic Listening® Quickshift or white noise, 13 participants reported feeling comfortable and one reported feeling uncomfortable. After listening to Therapeutic Listening® Quickshift or white noise, all 14 participants reported feeling comfortable. Additionally, all 14 participants rated their overall experience as comfortable. The participants in both groups generally described feeling more comfortable performing motor tasks after listening to sound.

Some participants also described apprehension prior to beginning the tasks the first time as they did not know what to expect. A practice effect also improved comfortability with performance of the BOT-2. Participants in both groups felt comfortable while listening to music.

Research question number 3: Does Therapeutic Listening® Quickshift improve the quality of movement during bilateral coordination tasks?

In reviewing video performances of the BOT-2 pre-test and post-test for the control and experimental groups, the research team observed that many participants demonstrated an improvement in fluidity and rhythmicity on the post-test on the finger pivot and asymmetrical tapping items. However, the researchers were unable to ascertain if this was due to the Therapeutic Listening® Quickshift protocol or a practice effect since improvements in movement quality occurred in both the experimental and control groups.

Discussion and Limitations

The results of this study did not demonstrate a significant improvement in bilateral coordination for healthy adults following a 20-minute intervention of Therapeutic Listening® Quickshift compared to listening to white noise. For most items on the BOT-2 bilateral coordination subsection, individuals were able to achieve the maximum score on the first trial of the pre-test (see Figure 2). The presence of this ceiling effect indicates that the BOT-2 bilateral coordination subsection is not an appropriate tool to measure improvement in bilateral coordination for healthy adults with no physical, sensorial, or attentional difficulties. There was a slightly greater improvement from pre-test to post-test for the experimental group, however, this increase was not significant. Use of a more sensitive tool or one designed to detect subtle improvement of bilateral coordination in healthy adults, is needed to determine that Therapeutic Listening® Quickshift can improve bilateral coordination. The results did indicate a strong practice effect for both the control and experimental groups where scores increased significantly from pre-test to post-test for both groups.

The surveys indicated that participants felt more comfortable performing motor tasks following a session of listening to sound in both the experimental and control groups. Since some participants revealed feeling apprehensive prior to completing the pre-test due to lack of knowledge about the motor tasks, it could be concluded that there exists a practice effect for participant comfort as well as actual test scores. It can also be concluded that listening to any sound protocol that is soothing for 20 minutes while browsing magazines can calm most individuals, regardless of whether it is specifically modulated music or simply a calming white noise.

Though, these results seem to suggest that Therapeutic Listening® Quickshift does not improve bilateral coordination in healthy young adults, it is likely that the study would benefit from more sensitive instrumentation. In order to effectively measure improvement in bilateral coordination as a result of Therapeutic Listening® Quickshift, future researchers and therapists need to work with either more sensitive assessment measures or populations more susceptible to changes in bilateral coordination. In doing so, the effectiveness of Therapeutic Listening® Quickshift and its implication for the field of occupational therapy can be demonstrated.

Limitations

A major limitation to this study was the lack of sensitivity of the BOT-2 to changes in bilateral coordination, due to a ceiling effect for many participants on the pre-test (see Figure 2). This made it impossible to detect a significant difference in improvement of bilateral coordination from the pre-test to post-test. The small sample size of the study was also limiting in that the statistical power of the study was too low to adequately detect significant change between groups. Another limitation is that the sample consisted of more females than males. There was only one male who participated in the experiment. This is reflective of the population of Dominican University of California and was expected by the research team. Inadvertently the research team recruited a small number of athletes to participate in the research study. These individuals were able to complete perfect scores on the pre-test. Additionally, due to limited research space, the research team had to use a large classroom space in order to conduct the experiment. The acoustics of the classroom were not ideal due to high classroom ceilings, linoleum floors, and outside noise. Also, since the research team only had one space, two individuals were tested in the same room simultaneously. Lastly, the white noise was very calming and may not have had the sought after neutral effect.

Summary, Conclusion, and Recommendations

Therapists continue to use sound based interventions to treat a wide variety of conditions and diagnoses. One of the most widely used sound based interventions, Therapeutic Listening®, has only limited research studies with evidence supporting its effectiveness. Therapeutic Listening® is a powerful tool, one which uses specially modulated music to entrain the brain to specific frequencies thereby improving function in a number of different areas. Since this therapy was used and shown effective with healthy adults, it was the goal of this pilot study to assess the effectiveness of Therapeutic Listening® Quickshift in the motor function of healthy adults (Vital Links Representative, Personal Communication, November 29, 2012). This research team sought to add to the body of knowledge surrounding sound based interventions to assist the profession of occupational therapy. As this was a pilot study, the research team did not wish to target vulnerable populations, but rather wanted to begin by establishing baselines among healthy adults.

The results did not demonstrate a significant change in bilateral coordination as a result of Therapeutic Listening® Quickshift. Likely conclusions for these results are that this study was underpowered and used a tool that was not sensitive enough to measure change in bilateral coordination of healthy adults. Future research should take this into consideration. A more sensitive tool with a larger sample size could improve results. Additionally, using a group with known difficulties in bilateral coordination such as a sample of adults or children with sensory processing difficulties may be more appropriate to this experiment in demonstrating effectiveness of Therapeutic Listening® Quickshift.

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Appendix A

INCLUSION CRITERIA – SELECTION FORM

Identification number:

Gender: ☐ Male ☐ Female

Age:

I have/have had the following condition(s) (Check all that apply).

☐ Any physical limitations or injuries that may hinder safe completion of jumping or movement activities

☐ If you have any reason to believe that you have difficulty processing sensory information

☐ Any other known condition or diagnoses that may affect cognition, attention, or hearing.

Signature: ___________________________________

Date:________________________

Appendix B

DOMINICAN UNIVERSITY of CALIFORNIA CONSENT TO BE A RESEARCH SUBJECT

Purpose and Background:

Ms. Madeleine Haas and Mrs. Amy Sequeira, graduate students in the Department of Occupational Therapy at Dominican University of California, are conducting a research study designed to look at the effects of specially modulated music on motor coordination. The researchers are interested in understanding the how music influences coordination.

I am being asked to participate because I am a healthy adult aged 18-21.

Procedures:

If I agree to be a participant in this study, the following will happen:

1. I will participate in a one-hour session involving a test of my motor coordination and a brief listening session (music).
2. I will be video recorded during my performance of the test of motor coordination. All personal references and identifying information will be eliminated when data is recorded, and all subjects will be identified by numerical code only, thereby assuring confidentiality regarding the subjects. The master list for these codes will be kept by Ms. Haas and Mrs. Sequeira in a password protected computer drive, separate from the test results and video recordings. Only the researchers and their faculty advisors will see the recorded data. One year after the completion of the research, all written and recorded materials will be destroyed.
3. I will be furnished with a written summary of the relevant findings and conclusions of this project. Such results may not be available for three to six months.

Risks and/or Discomforts:

1. I understand that my participation involves minimal physical risk and I should be honest with the researchers if any injury precludes me from safely jumping or running in place.
2. I will be listening to music at a volume rated for safety and I should let the researchers know if the volume bothers me at any time.

Benefits:

There will be no direct benefit to me from participating in this study. The anticipated benefit of this study is a better understanding of how music influences physiology.

Questions:

I have talked to Ms. Haas and/or Mrs. Sequeira about this study and have had my questions answered. If I have further questions about the study, I may contact her at madeleine.haas@students.dominican.edu or amy.sequeira@students.dominican.edu or their research supervisor, Dr. Julia Wilbarger, Professor in the Occupational Therapy department, Dominican University of California, at julia.wilbarger@dominican.edu.

If I have any questions or comments about participation in this study, I should talk first with the researchers and the research supervisor. If for some reason I do not wish to do this, I may contact the Dominican University of California Institutional Review Board for the Protection of Human Subjects (IRBPHS), which is concerned with the protection of volunteers in research projects. I may reach the IRBPHS Office by calling (415) 257- 1389 and leaving a voicemail message, by FAX at (415) 257-0165 or by writing to the IRBPHS, Office of the Associate Vice President for Academic Affairs, Dominican University of California, 50 Acacia Avenue, San Rafael, CA 94901.

Consent:

I have been given a copy of this consent form, signed and dated, to keep.

PARTICIPATION IN RESEARCH IS VOLUNTARY. I am free to decline to be in this study or withdraw my participation at any time without fear of adverse consequences.
My signature below indicates that I agree to participate in this study.

SUBJECT'S SIGNATURE______________________________DATE____________

SIGNATURE OF RESEARCHER_________________________DATE____________

In addition, I understand that I will be video recorded during the experiment. Video recording will be stored without use of my name.

☐ I consent to the use of video recording during this experiment

☐ I decline to be video recorded during this experiment, but would still like to participate.

SUBJECT'S SIGNATURE______________________________DATE____________

SIGNATURE OF RESEARCHER_________________________DATE____________

Appendix C

Survey Regarding Experiences

Before listening to music, I felt [circle one: comfortable/uncomfortable] performing the motor tasks asked of me. Please describe:

While listening to music, I felt [circle one: comfortable/uncomfortable]. Please describe:

After listening to music, I felt [circle one: comfortable/uncomfortable] performing the motor tasks asked of me. Please describe:

My overall rating for this experience is: [circle one: comfortable/uncomfortable].

Please provide any additional comments about your experience:

Table 1

Brain Wave Frequencies

Name	Rate	Attributes
Delta	0.5- 3 CPS	• Deep dreamless sleep • Very deep breathing • Slow heart rate • Cool body temperature
Theta (mainly in temporal and parietal regions of children's brains)	4-7 CPS	• Unconscious sleep state • Deep meditation • Deep creative dreams • Deep creative thought • In adults associated with great frustration as well as high creativity
Alpha	8-12 CPS	• Relaxation • Daydreaming • Creative imagination • Connection to subconscious • Information synthesis • First assimilation • Integrated learning status
Beta (most commonly recorded in frontal and parietal lobe)	13-40 CPS	• Logical thought processing • Analysis • Active • Organization skills • Productivity
High Beta	Over 23 CPS	• Anxiety • Anger • Short shallow breathing

Table 2

Summary of Means and Standard Deviations for Item and Total Scores on Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) Bilateral Coordination Subsection Scores

	Pre-test				Post-test			
	Control		Experimental		Control		Experimental	
Variable	M	SD	M	SD	M	SD	M	SD
Touching Nose	4.00	.00	4.00	.00	4.00	.00	4.00	.00
Jumping Jacks	3.00	.00	3.00	.00	3.00	.00	3.00	.00
Symmetrical Jump	3.00	.00	3.00	.00	3.00	.00	3.00	.00
Asymmetrical Jump	3.00	.00	3.00	.00	3.00	.00	3.00	.00
Finger Pivot	2.71	.49	2.71	.49	3.00	.00	3.00	.00
Symmetrical Tap	4.00	.00	4.00	.00	4.00	.00	4.00	.00
Asymmetrical Tap	2.86	.90	3.00	1.00	3.29	.95	3.71	.49
Total Point Score	22.57	1.13	22.71	1.25	23.00	1.29	23.57	0.79

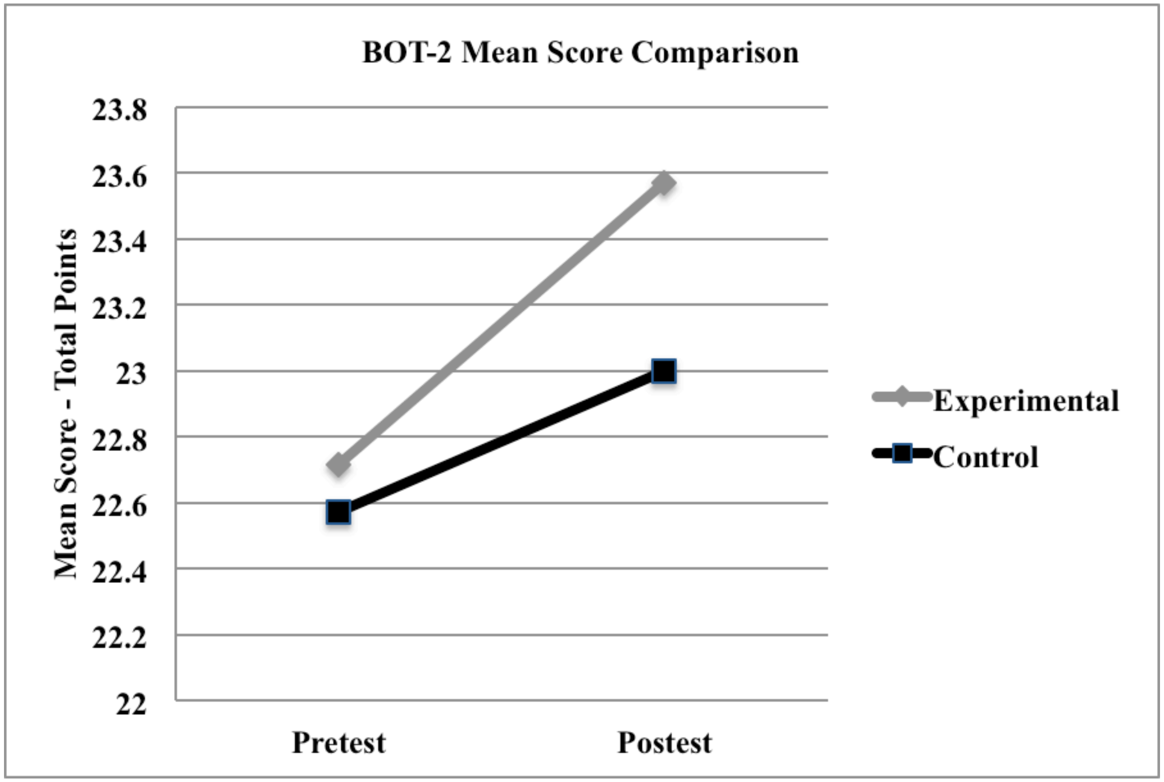

Figure 1. A comparison of means for the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) Bilateral Coordination Subsection total point scores for experimental and control groups.

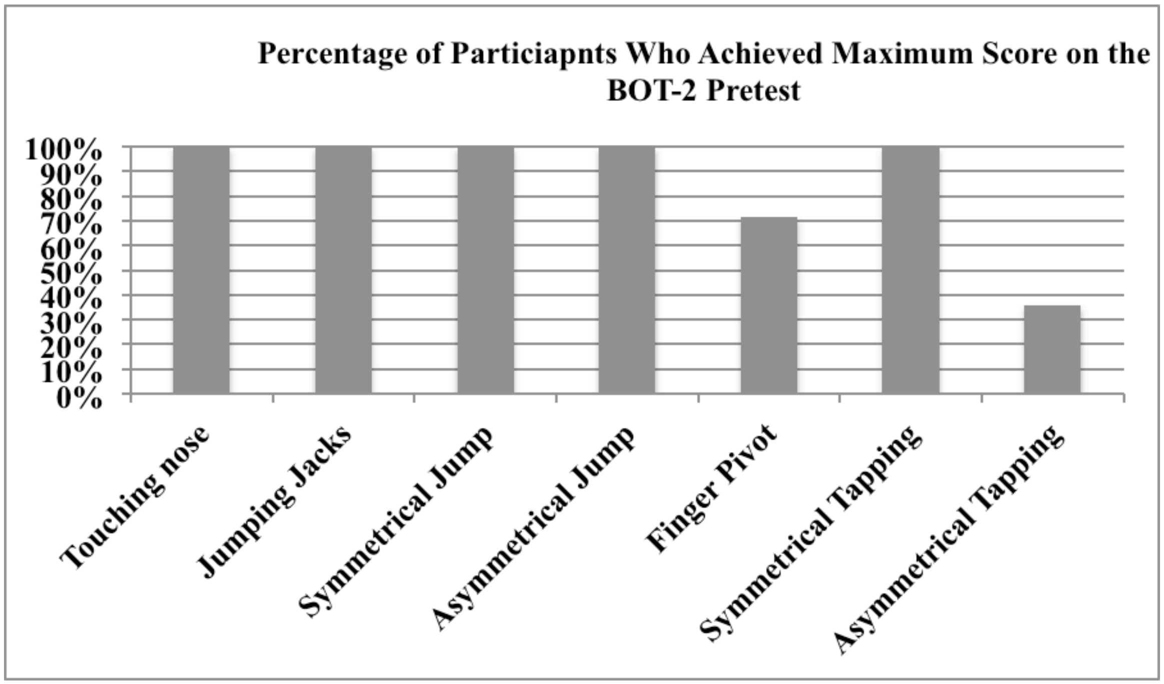

Figure 2. A bar graph demonstrating the percentage of participants who achieved the maximum score on the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) Bilateral Coordination Subsection by individual testing item.